

## SECTION 02650 - STEEL PIPE, MORTAR-LINED AND MORTAR-COATED

### City of San Diego, CWP Guidelines

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NTS: This Section is coordinated with Section 02600 such that it requires inclusion of that Section in the Contract Document.

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#### PART 1 -- GENERAL

##### 1.1 WORK OF THIS SECTION

- A. The WORK of this Section includes providing mortar-lined and mortar-coated steel pipeline, including fittings and specials, complete in place.

##### 1.2 RELATED SECTIONS

- A. The WORK of the following Sections applies to the WORK of this Section. Other Sections of the Specifications, not referenced below, shall also apply to the extent required for proper performance of this WORK.

- 1. Section 02140 Dewatering
- 2. Section 02200 Earthwork
- 3. Section 02600 Pipeline Construction
- 4. Section 02666 Water Pipeline Testing and Disinfection
- 5. Section 05500 Miscellaneous Metalwork
- 6. Section 09800 Protective Coating
- 7. Section 15000 Piping Components
- 8. Section 15025 Cathodic Protection System

##### 1.3 STANDARD SPECIFICATIONS

- A. Except as otherwise indicated in this Section of the Specifications, the CONTRACTOR shall comply with the Standard Specifications for Public Works Construction (SSPWC), as specified in Section 01090 - REFERENCE STANDARDS.

##### 1.4 SPECIFICATIONS AND STANDARDS

- A. Except as otherwise indicated, the current editions of the following apply to the WORK of this Section:

- 1. ASTM A 234 Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
- [2. ASTM A 370 Mechanical Testing of Steel Products]
- [3. ASTM E 165 Methods for Liquid Penetrant Inspection]

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| 4. | ANSI/AWWA C200 | Steel Water Pipe 6 In and Larger  |
| 5. | ANSI/AWWA C205 | Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 In and Larger - Shop Applied |
| 6. | ANSI/AWWA C206 | Field Welding of Steel Water Pipe   |
| 7. | ANSI/AWWA C208 | Dimensions for Fabricated Steel Water Pipe Fittings   |
| 8. | ANSI/AWWA C602 | Cement-Mortar Lining of Water Pipelines 4-In and Larger - In Place                                |
| 9. | AWWA M-11      | Steel Water Pipe - A Guide for Design and Installation.   |

#### 1.5 SHOP DRAWINGS AND SAMPLES

A. The following shall be submitted in compliance with Section 01300:

1. Shop drawings and catalog information on pipe and fittings.
2. Joint and fitting wall construction details which indicate the type and thickness of cylinder; the position, type, size, and area of reinforcement; manufacturing tolerances; and all other pertinent information required for the manufacture of the product. [Joint details shall be submitted where deep bell or butt strap joints are required for control of temperature stresses.]
3. Fittings and specials details such as elbows, reducers, wyes, tees, crosses, outlets, connections and test bulkheads, and nozzles or other specials where shown which indicate amount and position of all reinforcement. All fittings and specials shall be properly reinforced to withstand the internal pressure, both circumferential and longitudinal, and the external loading conditions as indicated in the Contract Documents.
4. Design calculations [including a complete stress analysis] of each critical section of pipe wall, girth joints, and specials - all sufficient to ascertain conformance of pipe and fittings with the Specifications.
5. Material lists and steel reinforcement schedules which include and describe all materials to be utilized.
6. Full and complete information regarding location, type, size, and extent of all welds shall be shown on the shop drawings. The shop drawings shall distinguish between shop and field welds. Shop drawings shall indicate by welding symbols or sketches the details of the welded joints, and the preparation of parent metal required to make them. Joints or groups of joints in which welding sequence or technique are especially important shall be carefully controlled to minimize shrinkage stresses and distortion.

#### 1.6 OWNER'S MANUAL

A. The following shall be included in the OWNER'S MANUAL in compliance with Section 01300:

1. Certifications: The CONTRACTOR shall furnish a certification stating that all pipe, special fittings, and other products or materials furnished under this Section of the Specifications comply with ANSI/AWWA C200 and C205. Additionally, the CONTRACTOR shall furnish certified reports of the following tests:
  - a. Physical and chemical properties of all steel.
  - b. Hydrostatic test reports.
  - c. Results of production weld tests.
- B. All expenses incurred in making samples for certification of tests shall be borne by the CONTRACTOR.

#### 1.7 FACTORY INSPECTION, TESTS AND WELDING REQUIREMENTS

- A. The CONTRACTOR shall be responsible for all costs associated with inspection and testing of materials, products, or equipment at the place of manufacture. This shall include costs for travel, meals, lodging, and car rental for [two] OWNER-designated inspectors for [ ] days required to complete such inspections or observations exclusive of travel days, if the place of manufacture, fabrication and factory testing is more than fifty (50) miles outside the geographical limit of the City. The CONTRACTOR shall not be responsible for salary or salary-related costs of the inspectors. The CONTRACTOR shall comply with the requirements of Section 01400.
- B. **Inspection:** All pipe shall be subject to inspection at the place of manufacture in accordance with the provisions of ANSI/AWWA C200 and C205, as supplemented by the requirements herein. The CONTRACTOR shall notify the CONSTRUCTION MANAGER in writing of the manufacturing starting date not less than 14 calendar days prior to the start of any phase of the pipe manufacture.
- C. **Tests:** Except as modified herein, all materials used in the manufacture of the pipe shall be tested in accordance with the requirements of ANSI/AWWA C200 and C205, as applicable.

##### 1. Shop testing of steel pipe:

- a. After the joint configuration is completed and prior to lining with cement-mortar, each length of pipe of each diameter and pressure class shall be shop-tested and certified to a pressure of at least 80 percent of the yield strength of the pipe steel.
- b. Production weld tests shall be conducted in compliance with ANSI/AWWA C200. In addition to the frequency of tests required in ANSI/AWWA C200, weld tests shall be conducted on each 5,000 feet of production welds and at any other times there is a change in the welding procedure or welding equipment.

##### 2. Shop testing of steel plate special:

- a. Upon completion of the welding, but prior to lining and coating, each steel plate special shall be bulkheaded and tested under a hydrostatic pressure of 1-1/2 times the design pressure; provided, that if straight pipe used in fabricating the specials has been previously tested and meets the requirements of the applicable piping Section, no further hydrostatic testing will be required; or provided, that all other welded seams are tested by the liquid penetrant inspection procedure conforming to ASTM E 165, under Method "B" and "Leak Testing" or where applicable by the soap and compressed air method at

an air pressure of 25 psi. Any pin holes or porous welds which may be revealed by the test shall be chipped out and rewelded and the pipe or fitting retested.

- b. No outside coating shall be applied over a seam prior to testing; however, mortar lining may be applied over a seam prior to hydrostatic testing, but under such conditions said pressure test shall be held on the pipe or fitting for a period of not less than 30 minutes.
  - D. The CONTRACTOR shall perform said material tests at no additional cost to the OWNER. The CONSTRUCTION MANAGER will witness all testing conducted by the CONTRACTOR; provided, that the CONTRACTOR'S schedule is not delayed for the convenience of the CONSTRUCTION MANAGER.
  - E. In addition to those tests specifically required, the CONSTRUCTION MANAGER may request additional samples of any material including mixed concrete and lining and coating samples for testing by the OWNER. The additional samples shall be furnished at no additional cost to the OWNER.
  - F. **Welding Requirements:** All welding procedures used to fabricate pipe shall be prequalified under the provisions of ANSI/AWS D1.1. Welding procedures shall be required for, but not necessarily limited to, longitudinal and girth or spiral welds for pipe cylinders, spigot and bell ring attachments, reinforcing plates and ring flange welds, and plates for lug connections.
  - G. **Welder Qualifications:** All welding shall be done by skilled welders, welding operators, and tackers who have had adequate experience in the methods and materials to be used. Welders shall be qualified under the provisions of ANSI/AWS D1.1 by an independent local, approved testing agency not more than 6 months prior to commencing work on the pipeline. Machines and electrodes similar to those used in the WORK shall be used in qualification tests. The CONTRACTOR shall furnish all material and bear the expense of qualifying welders.
- 1.8 FIELD TESTING
- A. Field testing shall conform to the requirements of Section 02666.
- 1.9 PRODUCT DELIVERY, STORAGE AND HANDLING.
- A. All pipe, fittings, etc., shall be carefully handled and protected against damage to lining and coating/interior and exterior surfaces, impact shocks, and free fall. The pipe and specials shall be handled by use of wide slings, padded cradles, or other devices designed and constructed to prevent damage to the pipe coating/exterior. The use of chains, hooks, or other equipment which might injure the pipe coating/exterior will not be permitted. Pipe shall not be placed directly on rough ground but shall be supported in a manner which will protect the pipe against injury whenever stored at the trench site or elsewhere.

## PART 2 -- PRODUCTS

### 2.1 GENERAL

- A. Mortar-lined and mortar-coated steel pipe shall conform to SSPWC subsection 207-10, subject to the following supplemental requirements.

- B. Specials are defined as fittings, closure pieces, bends, reducers, wyes, tees, crosses, outlets, manifolds, and other steel plate specials wherever located, and all piping above ground or in structures.
- C. Dimensions of fabricated steel pipe fittings shall comply with AWWA C208.
- D. The pipe shall be of the diameter shown, shall be furnished complete with rubber gaskets or welded joints, as indicated in the Contract Documents, and all specials and bends shall be provided as required under the Contract Documents. For pipe 14 inches in diameter and larger, the inside diameter after lining shall not be less than the nominal diameter indicated. Pipe smaller than 14 inches in diameter may be furnished in standard outside diameters.
- E. **Markings:** The CONTRACTOR shall legibly mark all pipes and specials in accordance with the laying schedule and marking diagram. Each pipe shall be numbered in sequence and said number shall appear on the laying schedule and marking diagram in its proper location for installation. All special pipe sections and fittings shall be marked at each end indicating the top. The word "top" shall be painted or marked on the outside top spigot end of each pipe section.
- F. Stockpiled pipe and specials shall be suitably supported on sand or earth berms free of rock exceeding 3 inches in diameter. The pipe shall not be rolled and shall be secured to prevent accidental rolling.
- G. The CONTRACTOR shall be fully liable for the cost of replacement or repair of pipe and specials which are damaged.
- H. **Strutting:** Adequate strutting shall be provided on all specials, fittings, and straight pipe so as to avoid damage to the pipe and fittings during handling, storage, hauling, and installation. In addition, the following requirements shall apply:
  - 1. The strutting shall be placed as soon as practicable after the mortar lining has been applied and shall remain in place while the pipe is loaded, transported, unloaded, installed and backfilled at the jobsite.
  - 2. The strutting materials, size and spacing shall be adequate to support the earth backfill plus any greater loads which may be imposed by the backfilling and compaction equipment.
  - 3. Any pipe damaged during handling, hauling, storage, or installation due to improper strutting shall be repaired or replaced.
  - 4. The details of the strutting assembly shall be submitted for review by the CONSTRUCTION MANAGER prior to the start of pipe manufacture.
- I. **Laying Lengths:** Maximum pipe lengths for laying shall be 40 ft with shorter lengths provided as required.
- J. **Offset Tolerances:** For pipe wall thicknesses of 3/8-inch or less, the maximum radial offset (misalignment) for submerged arc and gas metal arc welded pipe shall be 0.1875 times the pipe wall thickness or 1/16-inch, whichever is larger. For pipe wall thicknesses of greater than 3/8-inch, the maximum radial offset shall be 0.1875 times the wall thickness or 5/32-inch, whichever is smaller.

- K. **Lining:** The pipe lining shall have smooth dense interior surfaces and shall be free from fractures, excessive interior surface crazing and roughness.
- L. **Closures and Correction Pieces:** Closures and correction pieces shall be provided as required so that closures may be made due to different headings in the pipe laying operation and so that correction may be made to adjust the pipe laying to conform to pipe stationing shown on the Drawings. The locations of correction pieces and closure assemblies are shown on the Drawings. Any change in location or number of said items shall be submitted for review by the CONSTRUCTION MANAGER.

## 2.2 PIPE DESIGN CRITERIA

### A. General:

1. The pipe shall be steel pipe, mortar-lined and mortar-coated, with rubber gasketed or field welded joints as shown. The pipe shall consist of a steel cylinder, either shop-lined or lined-in-place with portland cement-mortar with an exterior coating of cement mortar.
2. The pipe shall be designed, manufactured, tested, inspected, and marked according to applicable requirements of ANSI/AWWA C 200 except as hereinafter modified.
3. The pipe shall be of the diameter and indicated pressure class. The minimum steel cylinder thickness for each pipe size shall be as indicated.

- B. **Cylinder Thickness for Internal Pressure:** For resistance to internal pressure, the thickness of the steel cylinder shall not be less than the greater of that determined by the following 2 formulas:

$$(1) \quad T = \frac{P_w D/2}{Y/S_w} \qquad (2) \quad T = \frac{P_t D/2}{Y/S_t}$$

Where:

- T = Steel Cylinder thickness in inches
- D = Outside diameter of steel cylinder in inches
- P<sub>w</sub> = Design working pressure in psi
- P<sub>t</sub> = Design transient pressure in psi
- Y = Specified minimum yield point of steel in psi
- S<sub>w</sub> = Safety factor of 2.0 at design working pressure
- S<sub>t</sub> = Safety factor of 1.5 at design transient pressure

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NTS: The effect of an S<sub>t</sub> of 1.5 (CWP design standard) means that the hoop stress for transient pressure can be allowed to rise by 33 percent above the stress for working pressure ( $y/1.5 \div y/2 = 1.33$ ). This differs from AWWA M11 which allows the hoop stress under transient loads to rise by 50 percent ( $0.75y \div 0.50y = 1.50$ ).

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- C. Unless otherwise indicated, P<sub>w</sub> shall be assumed to equal the indicated pipe pressure class and P<sub>t</sub> shall be assumed to equal 1.33 P<sub>w</sub>. In no case shall the design stress (Y/S<sub>w</sub>) exceed 16,500 psi at design working pressure, P<sub>w</sub>, nor shall the design stress (Y/S<sub>t</sub>) exceed 22,000 psi at design transient

pressure,  $P_i$ , nor shall the steel shell thickness be less than [No. 10 gauge (0.135 in.)] or the nominal pipe diameter divided by 240, whichever is greater, as shown in the following table:

<u>Nominal Pipe Diameter (in)</u>	<u>Minimum Cylinder Thickness (in)</u>
6	0.135
12	0.135
18	0.135
24	0.135
30	0.135
36	0.15
42	0.175
48	0.20
54	0.225
60	0.25
66	0.275
72	0.30
78	0.325
84	0.35
90	0.375
96	0.40
102	0.425
108	0.45
114	0.475
120	0.50

- D. **Cylinder Thickness for External Load:** Upon determination of cylinder thickness, for internal pressure, deflection of the pipe shall be checked by the following formula:

$$\text{Defl}_x = \frac{DKWr^3}{EI + 0.0614 E'r^3}$$

Where:  $\text{Defl}_x$  = Vertical deflection of pipe in inches, not to exceed 0.015 times the nominal diameter.

D = Deflection lag factor [1.25]

K = Bedding constant [0.1]

W = Vertical load on pipe, lb/in (see Notes 1 and 2)

r = Mean radius of pipe shell, inches

EI = Pipe wall stiffness, lb in (see Note 3)

E' = Modulus of soil reaction, lb/in<sup>2</sup> [1100 for 90 percent Standard Proctor; 1500 for 95 percent Standard Proctor; 2500 for 100 percent Standard Proctor, i.e., cement, crushed rock]

- Note 1: In the determination of the vertical load on the pipe, W, the trench condition shall normally apply unless an actual embankment condition exists or the trench width exceeds the transition width in which case the embankment condition shall apply. Yard piping shall always be designed for an embankment condition. The CONTRACTOR is cautioned that covers below 3 feet, if permitted, shall be investigated for concentrated wheel loads.
- Note 2: For depths of cover of 10 feet or greater, the earth load shall be computed assuming the trench/embankment condition as applicable. For depths of cover of less than 10 feet, HS-20 live load shall be included. For depths of cover of 3 feet or less, HS-20 live load plus impact shall be included. The determination of live load and impact factors shall be as recommended by AASHTO in "Standard Specifications for Highway Bridges."
- Note 3: Value of EI is based on the sum of the pipe wall stiffness, mortar lining and coating, and steel cylinder, assuming that it acts as a three-part laminar ring which considers no bond between the steel cylinder and the applied lining and coating. The term "pipe wall stiffness" as used herein is defined as EI, where "E" is the modulus of elasticity (E=30,000,000 psi for steel and E=4,000,000 psi for mortar) and "I" is the transverse moment of inertia per unit length of pipe wall, the factors in the foregoing expression to be dimensionally compatible.

Trench Condition:

$$W_d = C_d w B_d^2$$

Where:  $W_d$  = Earth Load in pounds per linear foot  
 $C_d$  = Calculation Coefficient  
 $Ku'$  = [0.13]  
 $w$  = [120] lb/ft<sup>3</sup>  
 $B_d$  = Trench width at top of pipe, feet

Positive Projecting Embankment Condition:

$$W_c = C_c w B_c^2$$

Where:  $W_c$  = Earth Load in pounds per linear foot  
 $C_c$  = Calculation Coefficient (based on  $r_{sd}p$  of 0.25)  
 $Ku$  = [0.19]  
 $w$  = [120] lb/ft<sup>3</sup>  
 $B_c$  = Outside diameter of pipe, feet  
 $r_{sd}$  = Settlement ratio  
 $p$  = Projection ratio

- E. If the calculated deflection,  $Defl_x$ , exceeds 0.015 times the nominal diameter, the composite pipe section shall be thickened or the quality of pipe zone backfill shall be improved to achieve a higher soil modulus (e.g., lean concrete, soil/sand cement, crushed rock).



## 2.3 DESIGN OF SPECIALS

- A. Except as otherwise provided herein, materials, fabrication and shop testing of straight pipe shall conform to the requirements of ANSI/AWWA C200. Dimensions for fittings shall conform to ANSI/AWWA C208. The minimum thickness of plate for pipe from which specials are to be fabricated shall be the greater of that determined by the following 2 formulas:

$$(1) \quad T = \frac{P_w D/2}{Y/S_w} \qquad (2) \quad T = \frac{P_t D/2}{Y/S_t}$$

Where:

T	=	Steel cylinder thickness in inches
D	=	Outside diameter of steel cylinder in inches
P <sub>w</sub>	=	Design working pressure in psi
P <sub>t</sub>	=	Design transient pressure in psi
Y	=	Specified minimum yield point of steel in psi
S <sub>w</sub>	=	Safety factor of 2.5 at design working pressure
S <sub>t</sub>	=	Safety factor of 1.875 at design transient pressure

- B. In no case shall the design stress at design working pressure (Y/S<sub>w</sub>) for mortar-coated steel pipe exceed 16,500 psi or 22,000 psi at design transient pressure (Y/S<sub>t</sub>), nor shall plate thickness be less than the thickness of adjacent mainline pipe or the following:

Nominal Pipe Diameter (in)	Pipe Manifolds Piping Above Ground Piping in Structures	Elbows Bends Reducers
24 and under	3/16-in	10-ga
25 to 48	1/4-in	1/4-in
over 48	5/16-in	5/16-in

- C. Pipe installed on saddle supports shall be designed to limit the longitudinal bending stress to a maximum of 10,000 psi. Design shall be in accordance with the provisions of Chapter 7 of AWWA M-11.

## 2.4 MATERIALS

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NTS: Type II cement should be specified for both the lining and coating except in those areas where soils analysis shows a soluble sulfate concentration exceeding 1000 ppm. In such locations, specify Type V cement for coatings and make it optional for linings.

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- A. **Cement:** Cement for mortar shall conform to the requirements of ANSI/AWWA C205; provided, that cement for mortar lining shall be Type [II] [V] and mortar lining shall be Type II [or V]. Fly ash or pozzolan shall not be used as a cement replacement.
- B. **Steel for Cylinders and Fittings:** Pipe manufactured under ANSI/AWWA C200 shall be fabricated from sheet conforming to the requirements of ASTM A 570, Grades 30, 33, 36 or 40, or from plate conforming to the requirements of ASTM A 36, A 283, Grades C or D, or A 572, Grade 42, or coil conforming to the requirements of ASTM A 139, Grades B or C. All longitudinal and girth seams, whether straight or spiral, shall be butt welded using an approved electric-fusion-weld process.

- C. All steel used for the fabrication of pipe shall have a maximum carbon content of 0.25 percent, a maximum sulfur content of 0.015 percent, and shall have a minimum elongation of 22 percent in a 2-inch gauge length.
- D. All steel exceeding ½-inch in thickness used in fabricating pipe shall be tested for notch toughness using the Charpy V-Notch test in accordance with ASTM A 370. The steel shall withstand a minimum impact of 25 ft lb at a temperature of 30 degrees F.
- E. Steel shall be fine-grained, fully killed and manufactured by the continuous casting process.

## 2.5 JOINT DESIGN

- A. The standard field joint for steel pipe shall be either a single-welded lap joint or a rubber-gasketed joint for all pipe sizes up to and including [54] [60] inch diameter and shall be a single-welded lap joint for pipe sizes above [54] [60] inch diameter. Mechanically coupled, or flanged joints shall be required where shown. Butt-strap joints shall be used only where required for closures or where shown. The joints furnished shall have the same or higher pressure rating as the abutting pipe.
- B. **Lap Joints:** Lap joints prepared for field welding shall be in accordance with ANSI/AWWA C200. The method used to form, shape and size bell ends shall be such that the physical properties of the steel are not substantially altered. Unless otherwise approved by the CONSTRUCTION MANAGER, bell ends shall be formed by an expanding press or by being moved axially over a die in such a manner as to stretch the steel plate beyond its elastic limit to form a truly round bell of suitable diameter and shape. No process will be permitted in which the bell is formed by rolling. Faying surfaces of the bell and spigot shall be essentially parallel, but in no case shall the bell slope vary more than 2 degrees from the longitudinal axis of the pipe.
- C. **Bell-and-Spigot Joints:** For bell-and-spigot ends with rubber gaskets, the clearance between the bells and spigots shall be such that when combined with the gasket groove configuration and the gasket itself, will provide watertight joints under all operating conditions when properly installed. The CONTRACTOR shall require the pipe manufacturer to submit details complete with significant dimensions and tolerances and also to submit performance data indicating that the proposed joint has performed satisfactorily under similar conditions. In the absence of a history of field performance, the results of a test program shall be submitted. Unless otherwise approved by the CONSTRUCTION MANAGER, bell ends shall be formed by an expanding press or by being moved axially over a die in such a manner as to stretch the steel plate beyond its elastic limit to form a truly round bell of suitable diameter and shape. No process will be permitted in which the bell is formed by rolling. Further, unless otherwise approved by the CONSTRUCTION MANAGER, spigot ends with rolled gasket grooves shall be non-destructively tested by the dye penetrant or magnetic particle method for the full circumference, especially at the weld seam area. The actual yield strength of the steel used in the spigot rolling operation (i.e. yield strength values in mill certifications and subsequent destructive test results) shall be limited to 50,000 psi.
- D. Shop-applied interior linings and exterior coatings shall be held back from the ends of the pipe as indicated or as otherwise acceptable to the CONSTRUCTION MANAGER.
- E. **Restrained Joints:** Where indicated, restrained joints shall be field-welded joints. Designs shall include considerations of stresses induced in the steel cylinder, the joint rings, and any field welds, caused by thrust at bulkheads, bends, reducers, and line valves resulting from the design working pressure. For field welded joints, design stresses shall not exceed 50 percent of the indicated minimum yield strength of the grade of steel utilized, or 16,500 psi, whichever is less, for the part being examined when longitudinal thrust is assumed to be uniformly distributed around the circumference of the joint. At the CONTRACTOR's option, the steel cylinder area may be progressively reduced from the point of maximum thrust to the end of the restrained length. All

joints to be field welded for thrust restraint shall have the joint rings attached to the cylinder with double fillet welds.

## 2.6 CEMENT-MORTAR LINING OF PIPE

- A. **Cement-Mortar Lining for Shop Application:** Except as otherwise required, interior surfaces of all steel pipe, fittings, and specials shall be cleaned and lined in the shop with cement-mortar lining applied centrifugally in conformity with ANSI/AWWA C205. During the lining operation and thereafter, the pipe shall be maintained in a round condition by suitable bracing or strutting. The lining machines shall be of a type that has been used successfully for similar work. Every precaution shall be taken to prevent damage to the lining. If lining is damaged or found faulty at delivery site, the damaged or unsatisfactory portions shall be replaced with lining conforming to these Specifications at no additional cost to the OWNER.

- B. The minimum lining thickness shall be as follows, with a tolerance of plus or minus 25 percent:

<u>Nominal Pipe Diameter (in)</u>	<u>Lining Thickness (in)</u>
4-12	5/16
13-16	3/8
17-24	1/2
over 24	3/4

- C. The pipe shall be left bare where field joints occur as indicated. Ends of the linings shall be left square and uniform. Feathered or uneven edges will not be permitted.
- D. Defective linings, as determined by the CONSTRUCTION MANAGER, shall be removed from the pipe wall and shall be replaced to the full thickness required. Defective linings shall be cut back to a square shoulder in order to avoid feather edged joints.
- E. The progress of the application of mortar lining shall be regulated in order that all hand work, including the repair of defective areas is cured in accordance with the provisions of ANSI/AWWA C205. Cement-mortar for patching shall be the same materials as the mortar for machine lining, except that a finer grading of sand and mortar richer in cement shall be used when field inspection indicates that such mix will improve the finished lining of the pipe.
- [F. **Cement-Mortar Lining for Field Application:** The materials and design of in-place cement-mortar lining shall be in accordance with ANSI/AWWA C602 and the following supplementary requirements:

1. Portland cement shall conform to Type II, ASTM C 150.
2. Pozzolanic material shall not be used in the mortar mix.
3. Admixtures shall contain no calcium chloride.
4. The minimum lining thickness shall be as indicated for shop-applied cement-mortar lining and the finished inside diameter after lining shall be as shown.]

- G. **Protection of Pipe Lining/Interior:** For all pipe and fittings with plant-applied or cement-mortar linings, the CONTRACTOR shall provide a polyethylene or other suitable bulkhead on the ends of the pipe and on all special openings to prevent drying out of the lining. All bulkheads shall be substantial enough to remain intact during shipping and storage until the pipe is installed.

## 2.7 EXTERIOR COATING OF PIPE

- A. **Exterior Coating of Exposed Piping:** The exterior surfaces of pipe which will be exposed to the atmosphere inside structures or above ground shall be thoroughly cleaned and then given a shop coat of rust-inhibitive primer and a finish coat conforming to the requirements of Section 09800.
- B. **Exterior Coating of Buried Piping:** All pipe for buried service, including bumped heads, shall be coated with a one-inch minimum thickness of reinforced cement-mortar coating. Unless otherwise indicated, exterior surfaces of pipe or fittings passing through structure walls shall be cement-mortar coated from the center of the wall or from the wall flange to the end of the underground portion of pipe or fitting. The coating shall be reinforced with a spiral wire reinforcement or welded wire fabric in accordance with ANSI/AWWA C205. The welded wire fabric shall be securely fastened to the pipe with welded clips or strips of steel. The wire spaced 2 inches on centers shall extend circumferentially around the pipe. The ends of reinforcement strips shall be lapped 4 inches and the free ends tied or looped to assure continuity of the reinforcement.

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NTS: The requirement for coal-tar epoxy protective coating in the following paragraph should be specified only upon the recommendation of a qualified corrosion engineer for the following three conditions:

1. High chloride soils subject to alternate wetting and drying where the chloride ion concentration in the soils exceeds 1000 ppm and the soil resistivity, based on a statistical analysis of field measurements taken in the maximum natural moisture state, is lower than 1000 ohm-cm.
2. Acidic soils where the soil pH is below 5 and there is a probability of groundwater movement, i.e., fluctuating water table within the pipe zone. This condition rarely occurs except in peat bogs or man-made environments such as cinders, mine wastes, and industrial dumps. Other protective methods are often available such as impermeable clay backfill or calcareous backfill in the pipe zone.
3. Cathodic interference environments which cannot be fully mitigated by drainage bonds or other corrosion control practices.

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- [C. **Coal-Tar Epoxy Protective Coating:** The exterior surface of all mortar-coated pipe and fittings shall be protected with a minimum of 25-mill thick 100 percent solids coat-tar epoxy coating. The coating may be applied to freshly placed, partially cured, or cured cement-mortar coating. Application shall be in accordance with the manufacturer's printed instructions.]

## 2.8 FABRICATION OF SPECIALS

- A. **General:** Specials and fittings shall conform to dimensions stipulated in ANSI/AWWA C208. Reinforcement for wyes, tees, outlets, and nozzles shall be designed in accordance with AWWA Manual M-11. Reinforcement shall be designed for the pressure indicated and shall be in accordance with the Standard Details. Specials and fittings shall be equal in pressure design strength and shall have the same lining and coating as the adjoining pipe. Unless otherwise shown, the minimum radius of elbows shall be 2.5 times the pipe diameter and the maximum miter angle on each section of the elbow shall not exceed 11-1/4 degrees.

- B. Specials and fittings that cannot be mechanically lined and coated shall be lined and coated by hand-application, using the same materials as are used for the pipe and in accordance with the applicable ANSI/AWWA C602 Standards. Coating and lining applied in this manner shall provide protection equal to that indicated for the pipe. Fittings may be fabricated from pipe that has been mechanically lined or coated. Areas of lining that have been damaged by such fabrication shall be repaired by hand-applications in accordance with applicable ANSI/AWWA C602 Standards.
- C. Access manholes with covers shall be as indicated. All threaded outlets shall be forged steel suitable for 3000 psi service.
- D. **Outlets, Tees, Wyes, and Crosses:** Outlets 12-inch and smaller may be fabricated from Schedule 30 or heavier steel pipe in the standard outside diameters, i.e., 12-3/4-inch, 10-3/4-inch, 8-5/8-inch, 6-5/8-inch, and 4-1/2-inch.
- E. The design of outlet reinforcement shall be in accordance with the procedures given in Chapter 13 of AWWA Manual M-11, except that the design pressure,  $P$ , used in the M-11 procedure shall equal the greater of  $1.25 P_w$  or  $0.9375 P_r$ . Unless otherwise indicated, outlets 2 inches in diameter and smaller need not be reinforced.
- F. In lieu of saddle or wrapper reinforcement as required by the design procedure in Manual M-11, pipe or specials with outlets may be fabricated in their entirety of steel plate having a thickness equal to the sum of the pipe wall plus the required reinforcement.
- G. Where required by the M-11 design procedure crotch plate reinforcement shall be furnished.
- H. **Steel Welding Fittings:** Steel welding fittings shall conform to ASTM A 234.
- I. **Ends for Mechanical-Type Couplings:** Except as otherwise required, where mechanical-type couplings are indicated, the ends of pipe shall be banded with Type C collared ends using double fillet welds. Where pipe 12-inch and smaller is furnished in standard schedule thicknesses, and where the wall thickness equals or exceeds the coupling manufacturer's minimum wall thickness, the pipe ends may be grooved.
- J. **Lining:** All requirements pertaining to thickness, application and curing of lining indicated for straight pipe shall apply to specials, with the following proviso. If the special cannot be lined centrifugally, it shall be lined by hand. In such case, the lining shall be reinforced with 2-in by 4-in No. 12 welded wire fabric positioned approximately in the center of the lining. The wires spaced 2-in on centers shall extend circumferentially around the pipe with the fabric securely fastened to the pipe. Splices shall be lapped 4 inches and the free ends tied or looped to assure continuity.
- K. **Coating:** All requirements pertaining to thickness, application and curing of coating for straight pipe shall apply to specials. Unless otherwise indicated, the coating on the buried portion of a pipe passing through a structure wall shall extend to the center of the wall or the wall flange, if one is indicated. Pipe above ground or in structures shall be field painted as required in Section 09800.
- L. **Marking:** A mark indicating the true vertical axis of the special shall be placed on the top and bottom of the special.

## 2.9 PIPE APPURTENANCES

- A. Pipe appurtenances shall be in accordance with the requirements of Section 15000.
- 2.10 MANUFACTURERS

- A. Products shall be of the following manufacture, type and model (or equal):
  - 1. Coat-tar epoxy coating: Amercoat 1972B
  - 2. Threaded pipe outlets: Vogt
  - 3. Foam plastic for ground bands: Dow Chemical Company, Ethafoam 222

## **PART 3 -- EXECUTION**

### **3.1 INSTALLATION OF PIPE**

- A. Immediately before placing each section of pipe in final position for jointing, the bedding for the pipe shall be checked for firmness and uniformity of surface. When the pipe is being laid, it shall be turned and placed where possible, so that any slightly damaged portion will be on top. The damaged area shall be repaired for the protection of any exposed steel. All damaged areas shall be repaired using materials and methods acceptable to the CONSTRUCTION MANAGER.
- B. Moderate deflections and long radius curves may be made by means of beveled joint rings, by pulling standard joints, by using short lengths of pipe, or a combination of these methods; provided that pulled joints shall not be used in combination with bevels. The maximum total allowable angle for beveled joints shall be 5 degrees per pipe joint. Bevels shall be provided on the bell ends. Mitering of the spigot ends will not be permitted. The maximum allowable angle for pulled joints shall be in accordance with the manufacturer's recommendations or the angle which results from a 3/4-inch pull out from normal joint closure, whichever is less. All horizontal deflections or fabricated angles shall fall on the alignment. [In congested city streets or at other locations where underground obstructions may be encountered, the chord produced by deflecting the pipe shall be no further than 6 inches from the alignment indicated.]
- C. All vertical deflections shall fall on the alignment and at locations adjacent to underground obstructions, points of minimum earth cover, and pipeline outlets and structures. The pipe angle points shall match the angle points indicated.
- D. For pipe 42 inches in diameter and larger, pipe struts shall be left in place until backfilling operations have been completed. Struts in pipe smaller than 42 inches may be removed immediately after laying, provided, that the deflection of the pipe during and after backfilling does not exceed that indicated. After the backfill has been placed, the struts shall be removed and shall remain the property of the CONTRACTOR.
- E. The openings of all pipe and specials where the pipe and specials have been cement-mortar lined in the shop shall be protected with suitable bulkheads to maintain a moist atmosphere and to prevent unauthorized access by persons, animals, water or any undesirable substance. The bulkheads shall be so designed to prevent drying out of the interior of the pipe. The CONTRACTOR shall introduce water into the pipe to keep the mortar moist where moisture has been lost due to damaged bulkheads.

### **3.2 RUBBER GASKETED JOINTS**

- A. **Rubber Gasketed Joints:** Immediately before jointing pipe, the spigot end of the pipe shall be thoroughly cleaned, and a clean rubber gasket lubricated with an approved vegetable-based lubricant shall be placed in the spigot groove. The volume of the gasket shall be "equalized" by moving a metal rod between the gasket and the spigot ring around the full circumference of the spigot ring. The bell of the pipe already in place shall be carefully cleaned and lubricated with a vegetable-based lubricant. The spigot of the pipe section shall then be inserted into the bell of the previously laid joint and telescoped into its proper position. Tilting of the pipe to insert the spigot into the bell will not be permitted. After the pipe units have been joined, a feeler gauge shall be inserted into the recess and moved around the periphery of the joint to detect any irregularity in the position of the rubber gasket. If the gasket cannot be "felt" all around, the joint shall be disassembled. If the gasket is undamaged, as determined by the CONSTRUCTION MANAGER, it may be reused, but only after the bell ring and gasket have been relubricated.

### 3.3 WELDED JOINTS

- A. **General:** Field welded joints shall be in accordance with ANSI/AWWA C206.
- B. Where exterior welds are performed, adequate space shall be provided for welding and inspection of the joints.
- C. During installation of welded steel pipe in either straight alignment or on curves, the pipe shall be laid so that the lap joint clearance, at any point around the circumference of the joint, shall comply with the requirements of AWWA C 206. Unless double fillet welds are indicated, field welded lap joints may, at the CONTRACTOR'S option, be made on either the inside or the outside of the pipe.
- D. Butt straps, where used or required, shall be a minimum of 6 inches wide, the same thickness as the pipe wall and shall provide for a minimum of 3/4-inch lap at each pipe joint. The pipe ends shall be cut straight on joints where butt straps are used for realignment, adjustment, or deflection, and fillet welds shall be made as indicated.
- E. After the pipe and pipe joint are properly positioned in the trench, the length of pipe between joints shall be backfilled to at least one foot above the top of the pipe. Care shall be exercised during the initial backfilling to prevent movement of the pipe and to prevent any backfill material from being deposited on the joint.
- F. To control temperature stresses, the unbackfilled joint areas of the pipe shall be shaded from the direct rays of the sun by the use of properly supported awnings, umbrellas, tarpaulins, or other suitable materials for a minimum period of 2 hours prior to the beginning of the welding operation and until the weld has been completed. Shading materials at the joint area shall not rest directly on the pipe but shall be supported to allow air circulation around the pipe. Shading of the pipe joints need not be performed when the ambient air temperature is below 45 degrees F.
- G. Prior to the beginning of the welding procedure, any tack welds used to position the pipe during laying shall be removed. Any annular space between the faying surfaces of the bell and spigot shall be equally distributed around the circumference of the joint by shimming, jacking, or other suitable means. The weld shall then be made in accordance with ANSI/AWWA C206. Where more than one pass is required, each pass except the first and final one shall be peened to relieve shrinkage stresses; and all dirt, slag, and flux shall be removed before the succeeding bead is applied.
- [H. As soon as practicable after welding of each joint, all field-welded joints shall be tested by the liquid penetrant inspection procedure conforming to the requirements of ANSI/ASTME 165 under Method "B" and "Leak Testing." All defects shall be chipped out, rewelded and retested. Upon retest, the repaired area shall show no leaks or other defects.]

- [I. Following tests of the joint, the exterior joint spaces shall be coated in accordance with these specifications after which backfilling may be completed.]

### 3.4 JOINT COATING AND LINING

- A. **General:** The interior and exterior joint recesses shall be thoroughly wiped clean and all water, loose scale, dirt and other foreign material shall be removed from the inside surface of the pipe. The cement for joint grout and mortar shall be portland cement acceptable under ASTM C150 and shall be of the same type used for the pipe coating.
- B. After the pipe has been laid and after sufficient backfill has been placed between the joints to hold the pipe securely in place, the outside annular space between pipe sections shall be completely filled with grout formed by the use of polyethylene foam-lined fabric bands. The grout shall be composed of one part cement to not more than 2 parts sand, thoroughly mixed with water to a consistency of thick cream. The grout space prior to filling shall be flushed with water so that the surface of the joint to be in contact with the grout will be thoroughly moistened when the grout is poured. The joint shall be filled with grout by pouring from one side only, and shall be rodded with a wire or other flexible rod or vibrated so that the grout completely fills the joint recess by moving down one side of the pipe, around the bottom of the pipe and up the opposite side. Pouring and rodding the grout shall be continued to allow completion of the filling of the entire joint recess in one operation. Care shall be taken to leave no unfilled space. Grouting of the outside joint spaces shall be kept as close behind the laying of the pipe as possible except that in no case shall grouting be closer than 3 joints of the pipe being laid.
- C. **Grout Bands (Diapers):** The grout bands or heavy-duty diapers shall be polyethylene foam-lined fabric with steel strapping of sufficient strength to hold the fresh mortar, resist rodding of the mortar and allow excess water to escape. The foam plastic shall be 100 percent closed cell, chemically inert, insoluble in water and resistant to acids, alkalies and solvents.
- D. The fabric backing shall be cut and sewn into 9-inch wide strips with slots for the steel strapping on the outer edges. The polyethylene foam shall be cut into strips 6 inches wide and slit to a thickness of 1/4-inch which will expose a hollow or open cell surface on one side. The foam liner shall be attached to the fabric backing with the open or hollow cells facing toward the pipe. The foam strip shall cover the full interior circumference of the grout band with sufficient length to permit an 8-inch overlap of the foam at or near the top of the pipe joint. Splices to provide continuity of the material will be permitted. The polyethylene foam material shall be protected from direct sunlight.
- E. The polyethylene foam-lined grout band shall be centered over the joint space with approximately equal widths extending over each pipe end and securely attached to the pipe with steel straps. After filling the exterior joint space with cement grout, the flaps shall be closed and overlapped in a manner that fully encloses the grout with polyethylene foam. The grout band shall remain in position on the pipe joint.
- F. **Joint Lining:** After the backfill has been completed to final grade, the interior joint recess shall be filled with mortar of stiff consistency mixed in proportions of one part cement to 2 parts sand. The mortar shall be tightly packed into the joint recess and troweled flush with the interior surface, and all excess shall be removed. At no point shall there be an indentation or projection of the mortar exceeding 1/16-inch. For pipe smaller than 24 inches in diameter, before the spigot is inserted into the bell, the bell shall be daubed with mortar containing one part cement to 2 parts sand. The spigot end then shall be forced to the bottom of the bell and excess mortar on the inside of the joint shall be swabbed out.



- [G. **Cement-Mortar Lining, Field-Applied:** For pipe diameters of [60] in or larger, the CONTRACTOR may construct the cement-mortar lining in-place. The application of in-place cement-mortar lining shall be in accordance with ANSI/AWWA C602.
- H. The lining machine shall be of a type that has been used successfully for a similar size of pipe. The CONTRACTOR shall perform all work in a thorough and workmanlike manner by trained personnel, under the supervision of experienced personnel skilled in machine application of cement-mortar lining to pipelines of size comparable to this work.
- I. Curing of the in-place cement-mortar lining shall be in accordance with ANSI/AWWA C602. The CONTRACTOR shall provide additional protective devices as required to ensure that the airtight covers, which maintain a moist condition in the pipeline, are not damaged.
- J. Defective areas encompassing the full diameter of the pipe shall be replaced by machine wherever the length measured along the pipe centerline is greater than 5 feet; otherwise defective areas may be replaced by hand.]

### 3.5 INSTALLATION OF PIPE APPURTENANCES

- A. **Protection of Appurtenances:** Where the joining pipe is concrete or coated with cement mortar, buried appurtenances shall be coated with a minimum thickness of one-inch of cement mortar having one part cement to not more than 2 parts plaster sand. [Following coating with cement mortar, the appurtenances shall be coated with coal-tar epoxy in accordance with Paragraph 2.7C.
- B. **Installation of Valves:** All valves shall be handled in a manner to prevent any injury or damage to any part of the valve. All joints shall be thoroughly cleaned and prepared prior to installation. The CONTRACTOR shall adjust all stem packing and operate each valve prior to installation to insure proper operation.
- C. All buried valves shall be coated and protected in accordance with Section 09800.
- D. All valves shall be installed so that the valve stems are plumb and in the location indicated.
- E. **Installation of Flanged Joints:** Before the joint is assembled, the flange faces shall be thoroughly cleaned of all foreign material with a power wire brush. The gasket shall be centered and the connecting flanges drawn up watertight without unnecessarily stressing the flanges. All bolts shall be tightened in a progressive diametrically opposite sequence and torqued with a suitable, approved and calibrated torque wrench. All clamping torque shall be applied to the nuts only.
- F. All buried flanges shall be coated and protected in accordance with Section 09800.
- G. **Insulated Joints:** Insulated joints and appurtenant features shall be made by the CONTRACTOR as shown on the Drawings. The CONTRACTOR shall exercise special care when installing these joints to prevent electrical conductivity across the joint. After the insulated joint is completed, an electrical resistance test will be performed by the OWNER. Should the resistance test indicate a short circuit, the CONTRACTOR shall remove the insulating units to inspect for damage, replace all damaged portions, and reassemble the insulating joint. The insulated joint shall then be retested to assure proper insulation.
- H. **Flexible Coupled Joints:** When installing flexible couplings, care shall be taken that the connecting pipe ends, couplings and gaskets are clean and free of all dirt and foreign matter with special attention being given to the contact surfaces of the pipe, gaskets and couplings. The couplings shall

be assembled and installed in conformity with the recommendation and instruction of the coupling manufacturer.

- I. Wrenches used in bolting couplings shall be of a type and size recommended by the coupling manufacturer. Coupling bolts shall be tightened so as to secure a uniform annular space between the follower rings and the body of the pipe with all bolts tightened approximately the same amount. Diametrically opposite bolts shall be tightened progressively and evenly. Final tightening shall be done with a suitable, approved and calibrated torque wrench set for the torque recommended by the coupling manufacturer. All clamping torque shall be applied to the nut only.
- J. Upon completion of the coupled joint, the coupling and bare metal of the pipe shall be cleaned, primed and protected in accordance with the requirements of Section 09800.
- K. **Bonding and Electrical Conductivity:** All unwelded pipe joints shall be bonded for electrical conductivity in accordance with the details indicated.

### 3.6 CORROSION CONTROL

- A. **Joint Bonding/Electrolysis Test Stations:** Except where indicated otherwise, all joints shall be bonded in accordance with the details indicated. The pipe shall be cleaned to bare bright metal at the point where the bond is installed. The pipe manufacturer shall be responsible for determining and implementing a suitable procedure and schedule for installation of bonding—field versus factory versus combination—in manner that the corrosion resistance of the lining and coating is not degraded by the bonding process. It may involve welding the bonding wires in the factory before applying the lining and coating specified and/or may involve patching impaired areas in the factory or the field. In addition, electrolysis test stations shall be installed where shown.
- B. **Cathodic Protection:** Corrosion mitigation and testing materials, such as an impressed current cathodic protection system, magnesium anodes, reference electrodes, and test lead wires shall be provided as indicated.

\*\* END OF SECTION \*\*